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Li

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(54) **PEM FUEL CELL STACK**

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(58) **Field of Classification Search**

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USPC 429/434, 437, 457, 514
See application file for complete search history.

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 180 days.

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(51) **Int. Cl.**

H01M 8/04 (2006.01)

H01M 8/02 (2006.01)

H01M 8/10 (2006.01)

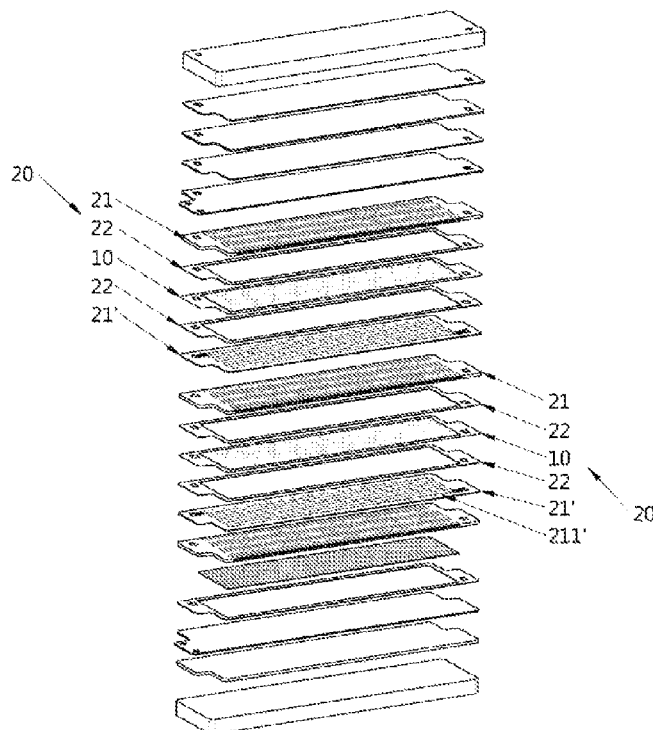
(52) **U.S. Cl.**

CPC *H01M 8/0258* (2013.01); *H01M 8/0267*

(57) **ABSTRACT**

A fuel cell includes a cathode flow field plate, an anode flow field plate, and a membrane electrode assembly (MEA) sandwiched between the cathode and anode flow field plate. The cathode flow field plate has a flat side and an opposed channel side that the MEA is sandwiched between the anode flow field plate and the flat side of the cathode flow field plate. The cathode flow field plate further has a plurality of flow channels formed at the channel side for enabling fluid flowing along the flow channels to promote electrochemical reaction through the MEA so as to generate electrical energy.

2 Claims, 7 Drawing Sheets



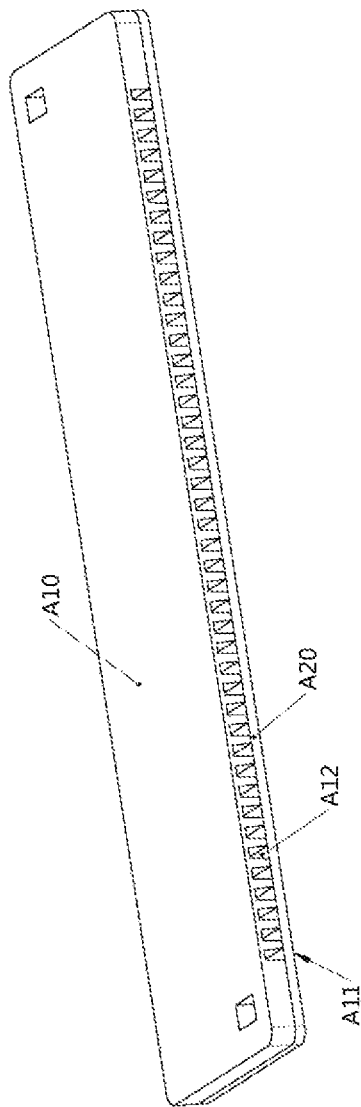


FIG. 1
PRIOR ART

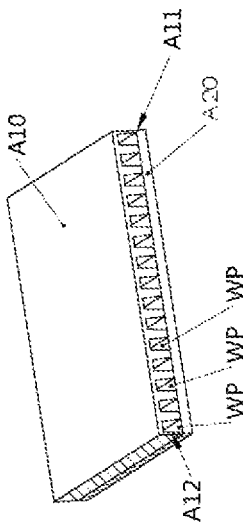


FIG. 2
PRIOR ART

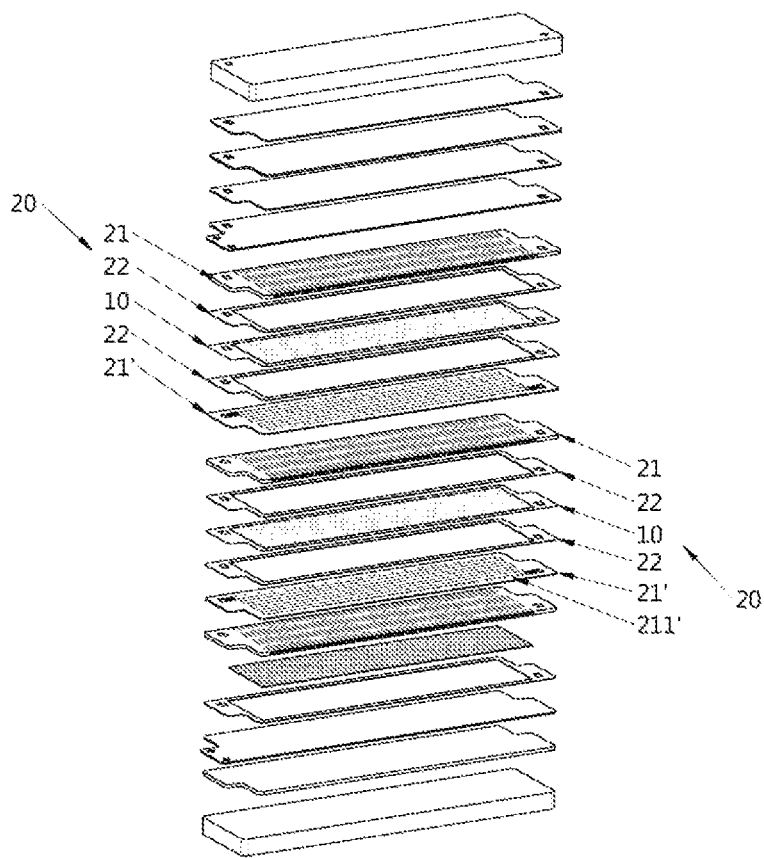


FIG.3

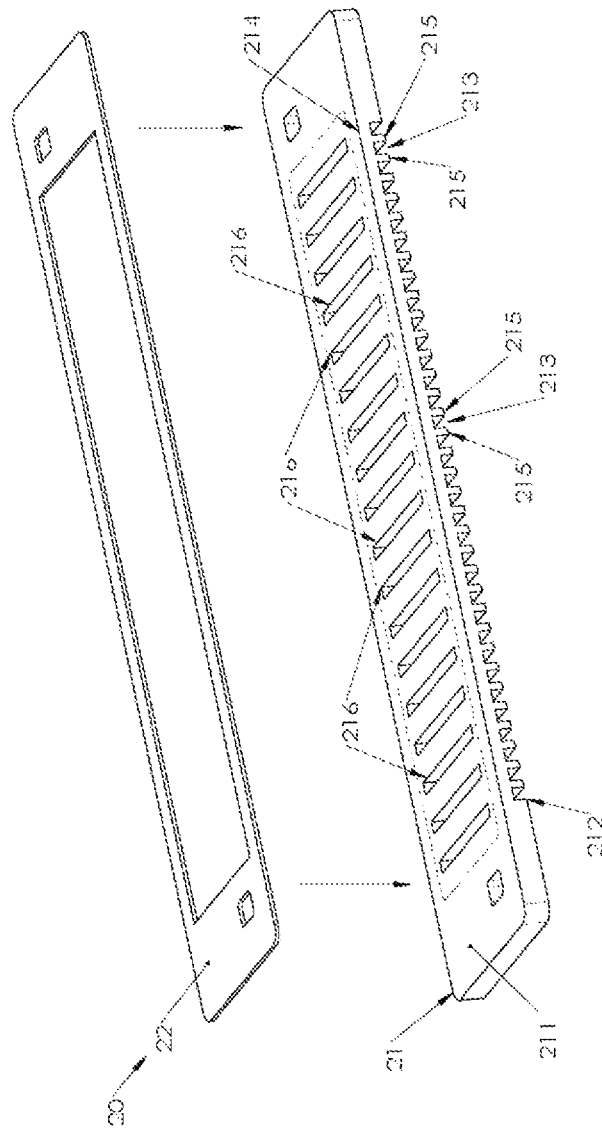


FIG. 4

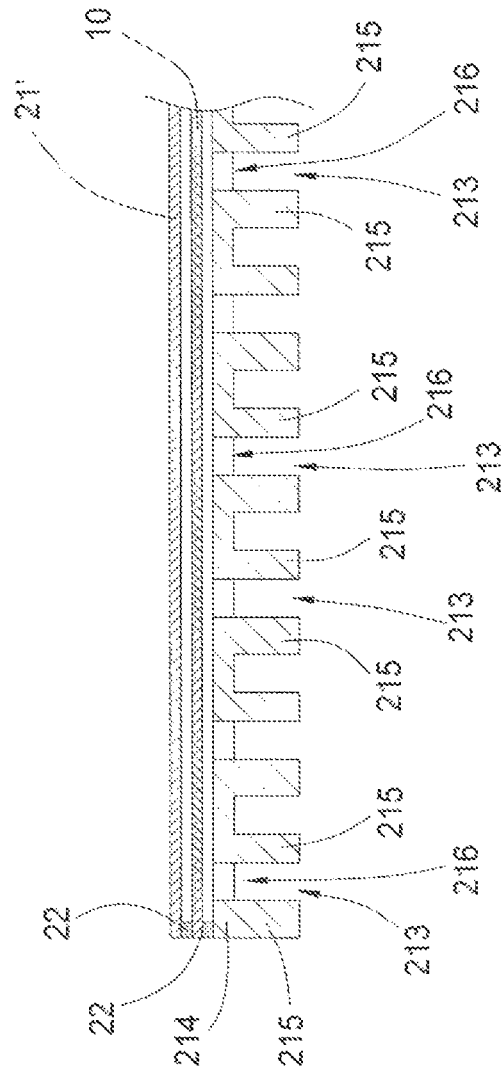


FIG. 5

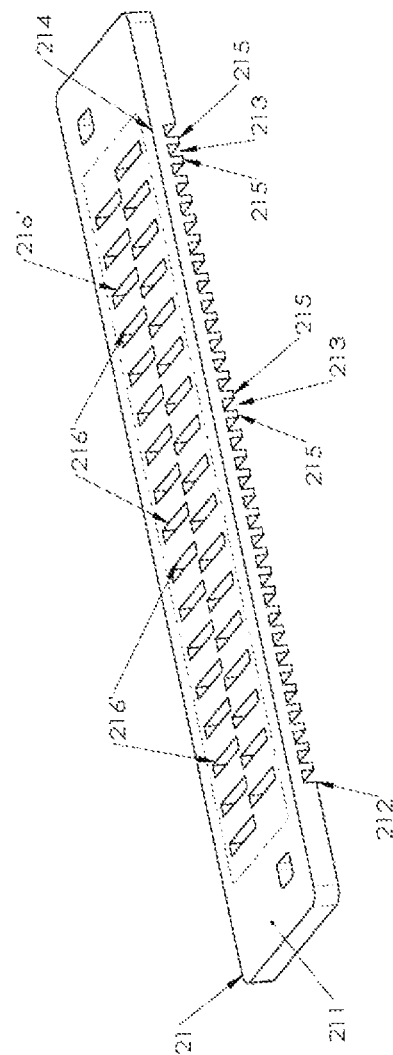


FIG. 6

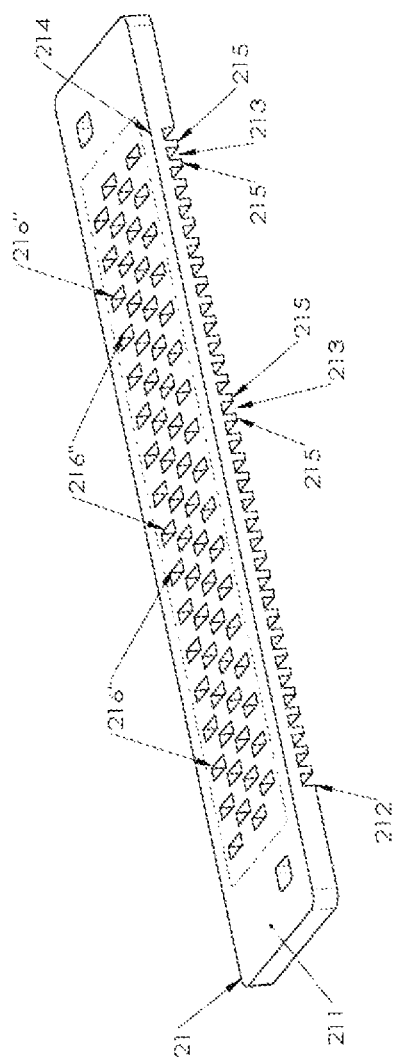


FIG. 7

1

PEM FUEL CELL STACK

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BACKGROUND OF THE PRESENT INVENTION

1. Field of Invention

The present invention relates to the field of fuel cells, and more particularly in the field of polymer membrane fuel stacks for use in a proton exchange membrane fuel cell.

2. Description of Related Arts

A fuel cell is an energy source that converts the chemical energy from a fuel into electricity through a chemical reaction with oxygen or another oxidizing agent. Hydrogen is most commonly used as the fuel for these types of cells. One of the most representative embodiments of this fuel cell technology is the proton exchange membrane (PEM) fuel cell. This kind of fuel cell is comprised of a membrane electrode assembly (MEA) which is further comprised of a polymer electrolyte membrane which is sandwiched between two catalyst coated papers, which correspond to an anode and cathode. The membrane electrode assembly (MEA) is then sandwiched between a pair of flow field plates which direct the fuel and oxidant respectively. The fuel cell operates according to the following steps: hydrogen fuel is channeled through a field flow plate to the anode on one side of the fuel cell, while oxidant is channeled through a flow field plate to the cathode on the other side of the cell; a platinum catalyst is located on the anode side which causes the hydrogen to split into positive hydrogen ions and electrons; the polymer electrolyte membrane allows only positively charged ions to pass through into the cathode, while the negatively charged electrons must travel along an external circuit to the cathode, wherein a electrical current is created; at the cathode, the electrons and positively charged hydrogen ions combine with oxygen to form water as the only product which is outputted from the cell. Additionally, as the oxygen is blown through the cathode flow field plate channels it also cools down the fuel cell. The cathode flow field plate furthermore may be exposed to the atmosphere in which case it is considered an "open cathode structure."

Conventional cathode flow field plate design is embodied as a saw or square-wave shaped structure in which air can be blown through by a blower or a fan. In comparison to water-cooled stacks, air-cooled stacks have a simpler balance of plan and an easier control strategy, and can be started up instantly.

One of the main flaws in an air-cooled proton exchange membrane fuel cell with polymer electrolyte membrane is thermal and water management. The polymer electrolyte membrane needs to be well hydrated in order to keep the internal electrical resistance of the membrane low. When air blows through the flow field plate channels, it cools the stack down, but also accelerates water evaporation leading to reduced water content in the membrane. Therefore, the fan speed needs to be carefully controlled (control strategy) according to current, ambient temperature, and relative humidity so that a balance can be reached. An inappropriate fan speed would reduce output power of the stack.

Another limitation of the air-cooled proton exchange membrane with polymer electrolyte membrane is hydrogen

2

leaking. In the conventional design, the saw-side of the cathode flow field plate faces the membrane electrode assembly, which is comprised of the polymer electrolyte membrane sandwiched between the catalyst layers. Therefore, only the saw teeth are pressed onto the gasket, the rest of the areas are potential weak points for hydrogen leakage. The design usually limits the hydrogen working pressure to less than 0.5 bar-g. However, higher hydrogen pressure can help improve the kinetics, cell uniformity, response to load change and reduce the probability of hydrogen starvation which is extremely detrimental to fuel cell durability, but pressure above this level may cause a leak or gasket to burst.

FIG. 1 is perspective view of the prior art of a flow field plate assembly of a proton exchange membrane fuel cell. The cathode flow field plate A10 has a saw side A11 forming a plurality of channels A12 thereat and contacting with the MEA. As the cathode flow field plate A10 is used for the MEA, these channels A12 allow for air to be channel to help dissipate heat generated by the reaction process. To cope with greater heat strain the amount of air channeled through these channels A12 must be increase which leads to evaporation of the water, thereby increasing the electrical resistance in the MEA.

To create a seal for the channels A12, a gasket A20 is layered on the side of the saw side A11 of the cathode flow field plate A10 that a tip of the channel wall are extended to couple with the gasket A20, wherein the gasket A20 is sandwiched between the saw side A11 of the cathode flow field plate A10 and the MEA.

FIG. 2 is a close-up perspective view of the cathode flow field plate assembly of a prior art of a proton exchange membrane fuel cell. This figure illustrates the weak points associated with the prior art of a proton exchange membrane fuel cell. The seal between the gasket A20 and the cathode flow field plate A10 is dependent upon the compression between the gasket A20 and the cathode flow field plate A10. Areas between the gasket A20 and the cathode flow field plate A10 where the tips of the channel walls come into contact with the gasket A20 are areas with a strong seal and when compression is increased the seal strength is increase allowing for a higher working pressure of the proton exchange membrane fuel cell. Areas with flow channel A12 are weak point WP areas due to the fact that there is no contact between the cathode flow field plate A10 and gasket A20, and thus there is no way for these areas to have their seal strength increased. When this seal strength between the tip of the channel wall of the cathode flow field plate A10 and the gasket A20 is enhanced leakage between the flow field plate A10 and the gasket A20 is prevented allowing for a higher working pressure and therefore improved fuel cell performance.

SUMMARY OF THE PRESENT INVENTION

The invention is advantageous in that it provides a fuel cell incorporating with a flow field plate assembly for use in a proton exchange membrane fuel cell to prevent any hydrogen leakage.

Another advantage of the invention is to provide a flow field plate assembly for allowing for a higher working pressure of the fuel cell and improving cooling efficiency. The performance improves for a greater power to weight ratio and enhances the overall viability of fuel cells as a prolific energy source.

Another advantage of the invention is to provide a flow field plate assembly for use in a proton exchange membrane fuel cell in which the proton exchange membrane fuel cell

3

would be able to operate at a pressure greater than 0.5 bar-g without risk of hydrogen leakage and thus safer to operate.

Another advantage of the invention is to provide a design for flow field plate assembly for use in a proton exchange membrane fuel cell in which the proton exchange membrane fuel cell would be able to operate at a pressure greater than 0.5 bar-g so that kinetics, cell uniformity, response to load change are improved and the probability of hydrogen starvation is reduced in comparison to conventional fuel cells.

Another advantage of the invention is to provide a design for a flow field plate assembly for use in a proton exchange membrane fuel cell in which the air-cooling efficiency is improved allowing for the use of thinner flow field plates decreasing the overall weight to power ratio.

Another advantage of the invention is to provide a design for a flow field plate assembly for use in a proton exchange membrane fuel cell in which the sensitivity of membrane water content to fan speed is reduced.

Another advantage of the invention is to provide a design a flow field plate assembly for use in a proton exchange membrane fuel cell in which the newly designed flow field plate can be adapted to mount on most conventional proton exchange membrane fuel cells.

Another advantage of the invention is to provide a design from that the newly designed flow field plate assembly for use in a proton exchange membrane fuel cell is easy, simple, and cheap to manufacture.

Additional advantages and features of the invention will become apparent from the description which follows, and may be realized by means of the instrumentalities and combinations particular point out in the appended claims.

According to the present invention, the foregoing and other objects and advantages are attained by an Air-Cooled PEM fuel cell stack.

According to the present invention, the foregoing and other objects and advantages are attained by a fuel cell which comprises a membrane electrode assembly (MEA) and a flow field plate assembly.

The flow field plate assembly comprises an anode flow field plate and a cathode flow field plate that the MEA is sealed between the anode and cathode flow field plates. The cathode flow field plate has a flat side and an opposed channel side that the MEA is sandwiched between the anode flow field plate and the flat side of said cathode flow field plate, wherein the cathode flow field plate further has a plurality of flow channels formed at the channel side for enabling fluid flowing along the flow channels to promote electrochemical reaction through the MEA so as to generate electrical energy.

Still further objects and advantages will become apparent from a consideration of the ensuing description and drawings.

These and other objectives, features, and advantages of the present invention will become apparent from the following detailed description, the accompanying drawings, and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a unit cell of the conventional proton membrane exchange fuel cell.

FIG. 2 illustrates the weak point of the conventional proton exchange membrane fuel cell.

FIG. 3 is an exploded perspective view of a PEM fuel cell stack in the preferred embodiment of the present invention.

FIG. 4 is a perspective view of the flow field plate assembly of the fuel cell stack in the preferred embodiment of the present invention.

4

FIG. 5 is a sectional view of the flow field plate assembly of the PEM fuel stack in the preferred embodiment of the present invention.

FIG. 6 illustrates a first alternative mode of the cooling channel of the flow field plate assembly of the PEM fuel stack in the preferred embodiment of the present invention.

FIG. 7 illustrates a second alternative mode of the cooling channel of the flow field plate assembly of the PEM fuel stack in the preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The following description is disclosed to enable any person skilled in the art to make and use the present invention. Preferred embodiments are provided in the following description only as examples and modifications will be apparent to those skilled in the art. The general principles defined in the following description would be applied to other embodiments, alternatives, modifications, equivalents, and applications without departing from the spirit and scope of the present invention.

As shown in FIG. 3, a PEM fuel cell stack in the preferred embodiment of the present invention is illustrated. The fuel cell stack comprises one or more fuel cell unit being stacked with each other. According to the preferred embodiment, each fuel cell unit, which can be formed as a single fuel cell, comprises a membrane electrode assembly (MEA) 10 and a flow field plate assembly 20 which comprises two electrically conductive dipolar plates for sandwiching the MEA 10 therebetween.

The MEA 10 comprises a polymer electrolyte membrane, and catalysts coated at two sides of the polymer electrolyte membrane. Two gas diffusion layers are located at two outer sides of the MEA 10 respectively, wherein the gas diffusion layers are held between the electrically conductive dipolar plates of the flow field plate assembly 20 to form a unit cell assembly.

The two electrically conductive dipolar plates for sandwiching the MEA 10 therebetween are an anode flow field plate 21' and a cathode flow field plate 21.

Preferably, the fuel cell stack in actual practice the proton exchange membrane fuel cell comprises a plurality of stacked unit fuel assemblies possibly numbering into the hundreds depending on the electrical consumption requirements. Therefore, a typical fuel cell stack comprises a series of repeating group unit cell assemblies.

According to the preferred embodiment, the MEA 10 is sealed and sandwiched between the flow field plates 21, 21'. The anode flow field plate 21' has a flat side 211'. The cathode flow field plate 21 has a flat side 211 and an opposed channel side 212 that the MEA 10 is sandwiched between the flat sides 211', 211 of the flow field plates 21, 21'. The cathode flow field plate 21 further has a plurality of flow channels 213 formed at the channel side 212 for enabling fluid flowing along the flow channels 213 to promote electrochemical reaction through the MEA 10 so as to generate electrical energy. Accordingly, the fluid is the reactive gas such as hydrogen gas, oxygen gas, or air.

As shown in FIG. 4, the cathode flow field plate 21 comprises a base body 214 defining the flat side 211 at an inner side of the base body 214, and a plurality of guiding walls 215 spacedly extended from an outer side of the base body 214 to define the channel side 212 of the flow field plate 21. The flow channels 213 are extended from one side edge of the base body 214 to another opposed side edge thereof. Accordingly, the flat side 211 of the flow field plate 21 is a flat surface. The

5

channel side 212 of the flow field plate 21 is a saw side thereof. In particular, each of the flow channels 213 is formed between two of the guiding walls 215. Preferably, the guiding walls 215 are parallel with each other and are integrally and perpendicularly extended from the outer side of the base body 214. The cross section of each of the guiding walls 215 is usually formed in rectangular, wherein each of the flow channels 213 has a uniform width. Alternatively, each of the guiding walls 215 has a trapezoid cross section that a width of the guiding wall 215 is gradually increased toward the base body 214. In other words, each of the flow channels 213 has a width gradually reduced toward the base body 214.

Therefore, the cathode flow field plate 21 further has a series of flows channels 213 which are spacedly and uniformly cut into a plate to create the cathode flow field plate. This flow field plate 21 may be constructed of any electron-conductive material that is also lightweight and strong. These flow channels 213 extend the entire lateral length of the flow field plate 21 and extend a predetermined depth into the flow field plate 21. The flow channels 213 also create ridges from the uncut material of the flow field plate 21 and these ridges are also spacedly placed and of uniform size.

As shown in FIGS. 4 and 5, the cathode flow field plate 21 further has a plurality of cooling channels 216 aligned and communicated with the flow channels 213 for dissipating heat of the flow field plate 21 when the fluid flows along the flow channels 213. Accordingly, each of the cooling channels 216 is an elongated slot evenly formed at the base body 214 to selectively communicate with the flow channels 213. In other words, when the cooling channels 216 are formed at the base body 214, the flow channels 213 will communicate with the cooling channels 216. Preferably, half of the total number of the flow channels 213 will communicate with the cooling channels 213 while the rest of the flow channels 213 will not communicate with the cooling channels 213.

In particular, the cooling channels 216 are through channels formed at the base body 214 to align with the flow channels 213 respectively, wherein the flat side 211 of the cathode flow field plate 21 is communicated with the channel side 212 thereof through the cooling channels 216. As a result, the heat dissipating area of the cathode flow field plate 21 will be substantially increased by the cooling channels 216 comparing with the same thickness of the conventional cathode flow field plate.

It should be appreciated that a plurality of cooling channels 216 are spacedly formed at the base body 214 to align with one corresponding flow channel 213. Accordingly, located in every other of the flow channels 213 is a through-all slot to form the cooling channel 216. This through-all slot allows for the cathode flow field plate to provide better efficient cooling effect. It is worth mentioning that the concept of the through-all slot located in the flow channel 213 of the cathode flow field plate 21 is not limited to this preferred embodiment but is extended to any embodiments of the cathode flow field plate 21 which contain a through-all slot cut into the flow channels 213 that allow for more efficient cooling of the MEA 10. This more efficient cooling allows for the objective of a decreased sensitivity of fan speed to be realized in this present invention. It is worth mentioning that with the increase of cooling efficiency and decreased sensitivity of fan speed the overall size of the fuel cell stack can be decreased while providing the same power output as a larger sized fuel cell constructed in accordance to the prior art. Therefore, the fuel cell of the present invention can be formed an Air-Cooled PEM fuel cell.

It is worth mentioning that the cooling channels 216 can be formed at every other of the flow channels 213 or at every flow channels 213. In other words, the number of cooling channels

6

216 can be selectively configured to incorporate with the flow channels 216. In addition, two or more cooling channels 216 can be formed at each flow channel 213 as well.

FIG. 6 illustrates a first alternative mode of the cooling channel 216' of the flow field plate assembly, wherein the cooling channel 216' are formed at every flow channels 213 respectively. In particular, each of the cooling channels 216' formed at either the first portion or the second portion of the flow channel 213, wherein the cooling channels 216' at the first portion of the flow channels 213 are alternated with the cooling channels 216' at the second portion of the flow channels 213. In addition, the length of each of the cooling channels 216' at the first portion of the flow channels 213 equals to the length of each the cooling channels 216' at the second portion of the flow channels 213.

FIG. 7 illustrates a second alternative mode of the cooling channel 216" of the flow field plate assembly, wherein two or more cooling channel 216" are formed at every flow channels 213 respectively. In particular, each of the flow channels 213 defines four equal portions that the cooling channels 216' formed at either the first and third portions or the second and fourth portions of the flow channel 213. Likewise, the cooling channels 216" at the first and third portions of the flow channels 213 are alternated with the cooling channels 216" at the second and fourth portions of the flow channels 213. All the cooling channels 216" have equal length.

It is worth mentioning that the thickness of the cathode flow field plate 21 can be substantially reduced by the structural configuration of the cooling channel 216. As shown in FIGS. 1 and 2 as an example, if the flow channel of the conventional plate is designed to have a 3 mm depth, a minimum 4 mm thick plate must be used in order to maintain the mechanical strength. In view of the present invention, if the flow channel 213 of the cathode flow field plate 21 is designed to have a 3 mm depth as an example, the thickness of the cathode flow field plate 21 will be configured to be 3 mm because of the cooling channel 216. In other words, the cooling channel 216 can be configured as a portion of the flow channel 213, so that the thickness of the cathode flow field plate 21 equals to the depth of the flow channel 213. In other words, the cathode flow field plate 21 of the present invention can be configured to be thinner than the conventional plate in order to achieve the same cooling area because the structural configuration of the cooling channel 216 of the present invention enables the use of the entire cross section of the cathode flow field plate 21 to dissipate the heat thereof when the air passes through the flow channels 213. As it is mentioned above, having the same thickness of the conventional plate, the cathode flow field plate 21 of the present invention will provide increased heat dissipating area for heat dissipation.

Preferably, a lateral length of each of the flow channels 213 is longer than a lateral length of the cooling channel 216. The lateral length of each of the flow channels 213 is the lateral length of flow field plate 21. In addition, a width of each of the flow channels 213 equals to or is larger than a width of the cooling channel 216. As shown in FIGS. 4 and 5, the through-all slots (the cooling channels 216) as well as the ridges created from the uncut material are more easily viewed.

According to the preferred embodiment, the flow field plate assembly 20 further comprises two sealing gaskets 22 sealed the cathode and anode flow field plates 21, 21' with the MEA 10. In particular, each of the sealing gaskets 22 is sealed and sandwiched between the flat side 211, 211' of the cathode and anode flow field plate 21, 21' and the MEA 10. In other words, one of the sealing gaskets 22 is sealed and sandwiched between the anode flow field plate 21' and the MEA 10 while

another sealing gasket **22** is sealed and sandwiched between the cathode flow field plate **21** and the MEA **10**.

As shown in FIG. 3, each of the sealing gaskets **22** has a hollow structure that seals at a peripheral edge of the flat side **211** of the cathode flow field plate **21**. In other words, the sealing gasket **22** has a hollow center region for the fluid, such as air, to flow therethrough. The sealing gasket **22** also has a corresponding size and shape matching with the flat side **211** of the cathode flow field plate **21**. As shown in FIG. 3, the sealing gasket **22** has a rectangular shape defining two lateral edge portions and two longitudinal edge portions to encircle the peripheral edge of the flat side **211** of the cathode flow field plate **21**. Preferably, each of the sealing gaskets **22** is adhered between the flat side **211** of the cathode flow field plate **21** and the MEA **10**.

It is worth mentioning that the cooling channels **216** are uncovered by the sealing gasket **22**. In other words, the cooling channels **216** are extended within the peripheral edge of the cathode flow field plate **21** and are extended between two longitudinal edge portions of the sealing gasket **22**.

FIG. 3 also depicts that with this design of the fuel cell stack in the preferred embodiment of the present invention that, despite what type of sealing method is used, such as an adhesive gasket, that gasket is under compression everywhere. It is worth mentioning that since the MEA **10** is sealed between the flat side **211**, **211'** of the cathode and anode flow field plate **21**, **21'** via the sealing gaskets **22**, a closed environment is created for the hydrogen to flow, so as to seal the anode flow field plate **21'** to prevent hydrogen leakage. Accordingly, the sealing gasket **22** of the present invention could be an endless ring or adhesive gasket. Adhesive gaskets work with moderate success but will start to develop leaks under moderate gas pressure if not compressed. O-rings provide a strong seal under very high pressures, but require a firm compression or they will not seal at all.

When the flow field plate **21** is used as the cathode flow field plate in the fuel cell, the flat side **211** of the cathode flow field plate **21** is mounted to the MEA **10**. The PEM fuel cell is configured to be open to atmosphere, so in addition to the oxidant being blown through the flow channels **213** of the cathode flow field plate **21**, the cathode structure configuration with the cooling channels **216** contributes to increase efficiency of air-cooling because the heat is dissipated and dissociated through the cooling channels **216**. With the increased cooling efficiency this allows for the cathode flow field plate **21** to be much thinner as compared with the conventional art. The advantageous implications of a thinner and lighter fuel cell stack are that they allow the fuel cell stack to be much more portable than prior art.

In particular, the cooling channels **216** are formed at the cathode flow field plate **21** to reduce the sensitivity of membrane hydration to fan speed. The cooling channels **216** are formed at every other flow channels **213**. When air passes through the flow channels **213** of the cathode flow field plate **21**, the air flow will only takes the heat away from the cathode flow field plate **21** via the cooling channels **216**. The flow channels **213** without the cooling channels **216** will keep the water content of the MEA **10** since the air will not contact with the MEA **10**.

In addition, the cathode flow field plate of the present invention will also provide thermal and water management for the fuel cell. Accordingly, the MEA **10** needs to be well hydrated in order to keep the internal resistance down. When the air blows through the flow channels **213**, it only cools the cathode flow field plate **21** down via the cooling channels **216** without accelerating water evaporation leading to reduce water content in the MEA **10**.

It is worth mentioning that the air flow will not contact with the MEA **10** through the flow channels **213** without the cooling channels **216** provided thereat when the air flow passes through the flow channels **213**. Therefore, when the fan speed is increased or decreased, only part of the air flow directly impacts the water content, while all the air flow still has the cooling effect. In other words, the cell voltage of the fuel cell becomes less sensitive to the fan speed, resulting in a more stable output voltage when fan control is interfered by electrical noise.

The adhesive sealing gasket **22** is sealed at the flat side **211'** of the anode flow field plate **21'** to prevent the hydrogen gas from leaking during operation. The sealing gasket **22** has an adhesive that is applied all around the edge of the flat side **211'** of the anode flow field plate **21'** so that when affixed to the anode flow field plate **21'** it is adhered all around the edges of the anode flow field plate **21'**. This adhesive method creates a stronger seal than the previous art provided enough compression is applied. The adhesive sealing gasket **22** also adheres the MEA **10** to the anode flow field plate **21'** sealing the hydrogen inside. With the weak points eliminated and the risk of hydrogen leakage reduced the MEA **10** can then be operated at a higher hydrogen pressure to achieve the listed goals of improved kinetics, cell uniformity, response to load change and reduction in the probability of hydrogen starvation in comparison to conventional fuel cells. The additional implication of a high operating pressure are that a smaller fuel cell stack would be able to generate the same amount of power as a larger fuel cell stack of the prior art.

It is worth mentioning that there is absolutely no weak point for the gas to leak. When the hydrogen pressure is increased up to 3 bar-g (i.e. six times more pressure than the conventional hydrogen pressure), there is no hydrogen leakage being detected. The open circuit voltage of every cell unit is above 1.0V. The stack can be run for a few thousand hours with the very stable performance. The standard deviation of the cell voltage has also been improved due to increased hydrogen pressure, reaching 5 mV at rated output, while the standard deviation of the conventional cell voltage is reported at 10-12 mV. It is worth mentioning that the smaller the standard deviation is the closer the cell voltages are. Therefore, the uniformity of the cell voltages in the stack of the present invention will be obtained by using higher hydrogen pressure. It is worth mentioning that the uniformity of the cell voltages isn't solely dependent on the hydrogen pressure, but higher hydrogen pressure does help to obtain the uniformity of the cell voltages. In other words, the output stack voltage is also very steady. According to the preferred embodiment, the hydrogen pressure can be increased above 0.5 bar-g which is the common limit of the hydrogen pressure for the conventional fuel cell.

It should be appreciated that the preferred embodiment of the present invention of the fuel cell, the material in which the anode plate and cathode plate are comprised of is generally a conductive type of metal. Characteristic of the metal are that it needs to be strong, lightweight, and electron-conducting, but the material is not restricted to metal. Materials such as conductive composites enhanced with such materials as graphite, carbon black, carbon fiber, and/or carbon nanotubes may be utilized in the construction of the present invention.

One skilled in the art will understand that the embodiment of the present invention as shown in the drawings and described above is exemplary only and not intended to be limiting.

It will thus be seen that the objects of the present invention have been fully and effectively accomplished. The embodiments have been shown and described for the purposes of

9

illustrating the functional and structural principles of the present invention and is subject to change without departure from such principles. Therefore, this invention includes all modifications encompassed within the spirit and scope of the following claims.

What is claimed is:

1. A cathode flow field plate assembly for a fuel cell having a membrane electrode assembly (MEA), comprising:

a cathode flow field plate having an inner side and an outer side, said inner side of said cathode flow field plate defining a flat side that said flat side of said cathode flow field plate is arranged for facing toward said MEA, said outer side of said cathode flow field plate defining a channel side, said cathode flow field plate further having a plurality of flow channels formed at said channel side for enabling fluid flowing along said flow channels to promote electrochemical reaction through said MEA so as to generate electrical energy, wherein said cathode flow field plate further has a plurality of cooling channels selectively aligned with said flow channels for dissipating heat of said cathode flow field plate when said fluid flows along said flow channels, wherein said cooling channels are through channels evenly formed at said cathode flow field plate to align with said flow channels, wherein said cooling channels are located in every other of the flow channels.

10

2. A cathode flow field plate assembly for a fuel cell having a membrane electrode assembly (MEA), comprising:

a cathode flow field plate having an inner side and an outer side, said inner side of said cathode flow field plate defining a flat side that said flat side of said cathode flow field plate is arranged for facing toward said MEA, said outer side of said cathode flow field plate defining a channel side, said cathode flow field plate further having a plurality of flow channels formed at said channel side for enabling fluid flowing along said flow channels to promote electrochemical reaction through said MEA so as to generate electrical energy, wherein said cathode flow field plate further has a plurality of guiding walls spacedly extended from said outer side of said cathode flow field plate to define said channel side, wherein each of said flow channels is formed between two of said guiding walls, wherein said cathode flow field plate further has a plurality of cooling channels selectively aligned with said flow channels for dissipating heat of said cathode flow field plate when said fluid flows along said flow channels, wherein said cooling channels are through channels evenly formed at said cathode flow field plate to align with said flow channels, wherein said cooling channels are located in every other of the flow channels.

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